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WINTER DAMAGE TO THE FORESTS OF MONTANA

FINAL REPORT

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USDA Forest Service
Northern Region
Timber, Cooperative
Forestry & Pest Management

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ABSTRACT

During January and early February 1989, a sequence of abrupt and drastic temperature changes caused widespread damage to the coniferous forests of Montana. A series of surveys were conducted during the summer of 1989 in heavily damaged stands to evaluate the nature of winter injury and to monitor its effects over a 4-year period. Damage estimates were made using a crown rating system based on the ratio of damaged foliage to green foliage and presence or absence of new growth.

Most of the winter injury occurred in lodgepole pine type in and near the Continental Divide. All species of native conifers were affected to some degree with the most severe injury occurring in mature and over-mature stands. Young trees in reproduction areas exhibited damage symptoms but incurred little, if any, significant damage. There was no apparent pattern to the distribution of winter injury; it seemed to occur without regard to elevation, aspect or topographic position.

Most of the trees with badly damaged crowns and exhibiting little new growth died within the first year, between 36 and 96 percent across plots. On plots not salvaged by 1991, between 8 and 32 percent of remaining trees died within the following 2 years. Trees that survived through 1993, with sparse, live crowns, will probably die in the immediate future.

No significant insect activity was observed in or near the affected stands during the year immediately following the winter damage. In western white pine, several winter-injured trees that were still alive in 1990, were attacked by mountain pine beetle (MPB) in 1991 and 1992. It is difficult to discern whether or not the trees were predisposed by the winter damage because the stand was in the middle of an extensive, ongoing outbreak. However, there was a increase in the number of western white pine trees attacked by MPB that were in the original winter damage areas, in 1991 and 1992.

On the Helena NF, a large area near Kershaw Mountain was affected by the winter damage in 1989. In 1991, many of the Douglas-fir trees in the winter-damage areas were attacked by Douglas-fir beetle (DFB). The winter injury, in combination with previous defoliation and several years of low precipitation, probably predisposed the trees to DFB attacks. DFB was not active in that area prior to the winter damage, but by 1991, there was a localized epidemic in and surrounding the winter-damage area (pers. comm., Ken Gibson).

The survey was limited to a few, heavily damaged stands and may not be representative of a much larger area that received less obvious, but significant, permanent injury. Many of these mature and over-mature stands, already weakened by drought, age and overstocking, will survive but with even less vigor, thereby increasing their vulnerability to a wide variety of destructive agents.

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INTRODUCTION

This is the third in a series of reports describing the results of surveys to record winter damage to coniferous forests in parts of Montana. The first two surveys were conducted in 1989 and 1990 and reported in 1990[1] and 1991[2]. Follow-up surveys were conducted in 1991 and 1992 but were not reported. This report will be comprehensive in content by including relevant information described in the two previous reports as well as a summary of findings to date.

BACKGROUND

During winter of 1988-89, a sequence of meteorological phenomena caused widespread injury to a variety of vascular plants throughout Montana. Many kinds of trees were affected--fruit trees in orchards, deciduous and coniferous trees used as ornamentals and native forest conifers. Most damage occurred near and along the Continental Divide in parts of the Helena, Deerlodge and Lewis and Clark National Forests.

This widespread injury is believed to have been caused by an abrupt and drastic change of air temperatures during late January and early February 1989. Five weather stations[3] recorded above average temperatures through January with even higher temperatures recorded during January 28-30. A surge of continental polar air then pushed into the region dropping temperatures below -20°F, a difference of 74 degrees in less than 24 hours. In Helena, a difference of 70 degrees was recorded. On February 3, Missoula recorded a wind chill factor of -77°F. Following this cold surge, temperatures during February returned to near normal. Sustained, subzero air temperatures during early February in Montana are not unusual, but the sudden and severe change over such a short time span is considered a "near record."[4]

Tree damage was first observed in late April and early May. In early July, an aerial sketchmap survey was made by National Forest personnel in Helena to locate and map the most heavily damaged areas on the Helena, Deerlodge, and Lewis and Clark National Forests. Later, during the summer, Forest Pest Management aerial sketchmappers mapped the damage statewide. Additionally, widely scattered and less serious winter injury was detected on parts of the Custer, Gallatin and Flathead National Forests (Figure 1, Table 1).

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[1]*Klein, William H. 1990. A survey of Winter Damage in the Forests of Montana, 1989. USDA For. Serv., North. Reg., Missoula, MT. Rept. 90-6, 11 pp., illustrated.*

[2]*Klein, William H. and Nancy J. Campbell. 1991. A Followup Survey of Winter Injury in the Forests of Montana, 1990. USDA For. Serv., North. Reg., Missoula, MT. Rept. 91-03, 11 pp., illustrated.*

[3]*Monthly climatological date from National Weather Service offices in Billings, Great Falls, Havre, Helena and Missoula, MT.*

[4]*Personal communication with Lloyd Heavner, Meteorologist in Charge, National Weather Service, Missoula, MT.*

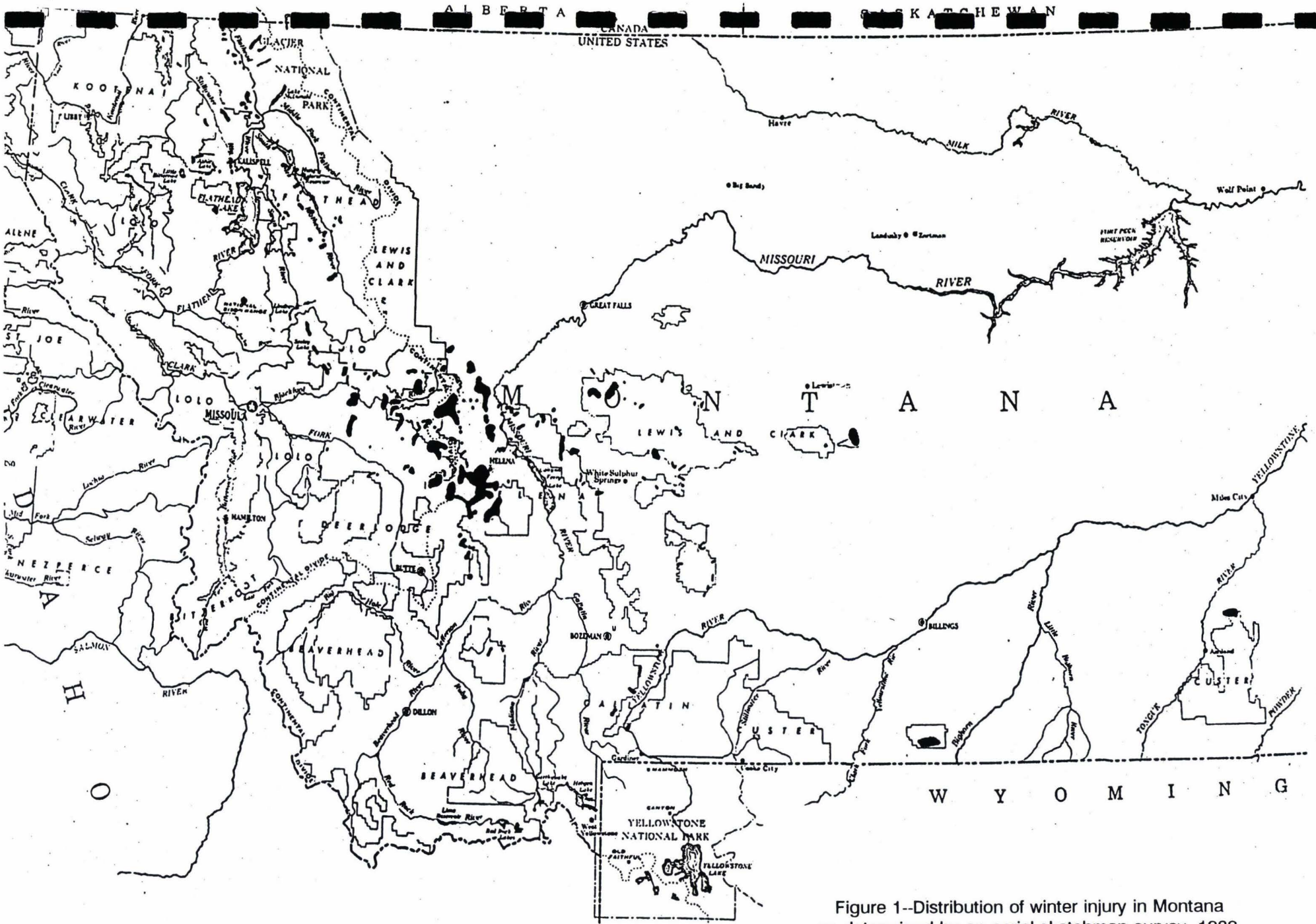


Figure 1--Distribution of winter injury in Montana as determined by an aerial sketchmap survey, 1989.

Table 1--Acres of winter injury in Montana during 1989 by intensity class as determined by aerial survey.

Area	Light	Moderate[1]	Heavy	Total
Beaverhead NF[2]	219	4,253	354	4,826
Bitterroot NF	---	1,324	---	1,324
Custer NF	---	9,541	---	9,541
Deerlodge, NF	1,729	6,167	4,562	12,458
Flathead NF	68	32,936	---	33,004
Gallatin NF	1,085	12,527	135	13,747
Helena NF	89,383	97,579	92,317	279,279
Lewis & Clark NF	39,047	51,437	9,461	99,945
Lolo NF	828	15,950	8,866	25,644
Totals	132,359	231,714	115,695	479,768

[1] In those Forests where winter damage was mapped without regard to intensity, the acreage was entered in the moderate column.

[2] Includes lands of all ownerships on the National Forest map.

METHODS

Following the initial aerial survey, Forest and District personnel met with a Regional entomologist to plan a survey to evaluate the nature of injury in some of the most heavily injured stands and to develop a methodology by which the effects of winter injury on individual trees and stands could be monitored and documented over time.

Survey procedures were initiated in and immediately adjacent to 13 heavily damaged stands during summer and fall 1989 and 1990. During 1991 and 1992, 5 of 13 stands were either partially or totally harvested, leaving 8 stands for re-examination in 1993.

A subjective rating system was developed for classifying tree crowns as to degree of damage and presence or absence of new growth. Each tree crown was closely observed, and depending on the ratio of damaged (dessicated or dead) foliage to green foliage, it was assigned one of eight condition categories. Each category reflected the ratio of live/green foliage to dead/dessicated foliage and was dependent on the percent of crown containing either undamaged or damaged foliage, as follows:

1. 25 percent
2 26 to 50 percent
3. 51 to 75 percent,
4. 76 percent.

As examples, a completely green crown would be rated 4,0 since more than 76 percent of the crown was green and contained no dead foliage. In direct contrast, a completely dead crown would be rated 0,4. Furthermore, a crown estimated to be approximately 30 percent green with the remaining portion dead (70 percent) would receive a 2,3 rating. A crown showing approximately equal numbers of live and dead needles would be rated 2,2.

All tree crowns were scanned for new growth using binoculars. This procedure required optimum light and weather conditions, i.e., full sunlight with blue sky background.

A stand re-examination survey, stand damage assessment was initiated in 1989 utilizing the above crown assessment criteria.

Stand Re-examination: In these surveys, 25 winter-injured trees were randomly selected and permanently tagged for relocation, to observe their condition over time. To facilitate relocation, azimuths were recorded between trees.

An attempt was made to select trees showing a range of crown damage, but in the most severely affected stands, this was not always possible. All trees, with the exception of those harvested during interim years, were re-examined annually.

Stand Damage Assessment: These surveys provided ready estimates of both degree and extent of injury to the stand. Observations were made of 20, five-tree groups at periodic intervals (2 or more chains) along a single transect or pair of parallel transects. The crowns of 100 trees were observed and rated. The trees were not permanently tagged for re-examination.

In 1993, it was decided to repeat the stand damage assessment surveys to supplement the more definitive stand re-examination surveys, since three of the stands had been harvested prior to 1993. Although it was not possible to relocate the original trees, the transects were re-established in the same stands, and the resulting data is believed to be a fair representation of the progressive effects of winter injury during this 5-year period.

A list of the survey plots together with pertinent geographical and topographical information is shown in the appendix.

Photo Plots: More than 20 photo points were established in 1989 to provide a visual record of damage symptoms and whatever changes that eventually followed. Scenes ranged from individual trees to vistas of entire stands. Each photopoint was marked with a wood stake and its direction (azimuth) referenced from a prominent terrain feature. A color print of the original scene (1989) was taken to the point and used by the photographer to frame the original scene.

Growth Analysis: Growth was measured in the stand re-examination plots and in the surrounding areas that were not salvaged during 1993. Two cores, were taken from opposite sides of the tree at breast height, parallel to the topographic contour. Cores were taken from between 10-20 trees per stand, placed in straws and put in a freezer until they were measured the following winter. Annual growth was measured to 0.1 mm for each core and total age was measured from one core for each tree.

FINDINGS AND OBSERVATIONS

During the initial plot establishment in late July 1989, only a few of the affected trees exhibited new growth. In those trees, the growth was mostly stunted, contorted and in the uppermost crown. As summer turned into autumn, more trees with new growth were recorded indicating an unseasonable surge of growth. Normally, in lodgepole pine, growth and shoot elongation ceases by late July (Oreily and Owens 1985) or early August (Horton 1958). To check this anomaly, three trees in five re-examination plots were re-examined. Most were found to have produced new growth not observed during the initial survey (Table 2). In most of the affected trees, new growth occurred throughout August and into September.

Table 2--Changes in shoot growth in five re-examination plots during two examination periods (25 trees per plot).

		New Growth Recorded				
		Examination Period				
Plot No.[1]	Tree spp.	1	2	1	2	Change
		Date		Number of Trees		
1	LP	7/16	9/1	3	22	+ 19
2	LP	7/28	9/11	8	20	+ 12
3	DF	8/4	9/11	4	6	+ 2
4	S	8/9	9/12	18	23	+ 5
5[2]	LP	8/17	9/12	15	15	0

[1] The trees in plots 1-4 were also in stands 1-4, respectively, listed in Appendix B. However, they were different trees.

[2] In this plot, three trees exhibited shoot growth since the initial examination (8/17), but the new growth recorded in these trees during the first examination appeared to have died in the interim. Those trees appeared to be dead.

In four of the re-examination plots, it was possible to record the sequence of mortality over a 5-year period (Table 3). In the four lodgepole pine plots, 75 percent of the trees were dead in 1990 and by 1993, 88 percent of the trees died. In the Douglas-fir plot (Cave Gulch), 12 (48 percent) of the trees were dead in 1990. The plot was salvage logged in 1991, before it could be re-evaluated. Of the 25 Engelmann spruce trees, (Copper Creek), 12 (48 percent) died the first year and by 1993, only six trees, 24 percent, survived. In the Betty Creek plot (western white pine) all 25 trees were alive and appeared to be surviving in 1990, but 15 trees were attacked and killed by the mountain pine beetle, *Dendroctonus ponderosae*, during 1991 and 1992. This particular area, along with other western white pine stands in the Flathead National Forest, have endured a long-standing MPB outbreak (Gibson and Oakes 1994), and it is possible that the winter-injured trees may have been vulnerable to MPB attacks. It is not known, however, if they and other winter-damaged western white pine on the Forest will exacerbate or prolong the outbreak.

Winter-caused mortality was not as severe in the stand assessment plots as in the stand re-examination plots (Table 4). In the three lodgepole pine assessment plots, 57 percent of the trees eventually died. In the mixed plot (Copper Creek), 48 percent of the trees were killed. The Cave Gulch and Cataract Creek plots were salvage logged prior to 1993. This may be due to the fact that the stand re-examination plots were established in areas that were severely affected by winter damage and the stand assessment plots were in the surrounding areas.

Practically all conifer species within the surveyed areas were affected to some degree, and all of the permanent damage (mortality) occurred in mature and over-mature stands, regardless of tree species. In reproduction areas adjacent to the severely affected mature stands, some mortality occurred but it was negligible. Practically all of the winter-injured young trees shed their damaged needles and exhibited normal growth by 1990. Possibly the only permanent damage to these younger stands was some growth setback.

The fate of the few remaining live trees in the lodgepole pine and Engelmann spruce re-examination plots is uncertain, but it is suspected that most will die, particularly those with sparse live crowns. The remaining western white pines in the Betty Creek plot may survive, but only if they are passed over by the on-going MPB infestation.

Although no plots were established in ponderosa pine stands, periodic observations showed little, if any, mortality east of the Continental Divide many ponderosa pine showed obvious crown injury in 1989, but unlike the other species, they developed considerably more new growth. There were many individual trees, that from afar, appeared to have been critically injured, but survived (Figures 2 and 3). Some mortality of ponderosa pine reproduction occurred, but it was widely scattered and judged insignificant.

Table 3--Estimates of crown condition and tree mortality of winter-damaged (1988-89) conifers in eight re-examination plots established in 1989.

					Crown Damage Rating											
					----------Live----------								Dead	New Growth		
Location	Tree spp.	DBH (in)	Year Exam.	Trees Exam.	4,0	4,1	3,1	3,2	2,2	2,3	1,3	1,4	0,4	Yes	No	Year Exam.
Bryan Cr.[1]	LP	9.4	1989	25	0	2	3	0	7	0	7	6	0	22	3	1989
			1990		0	2	0	0	2	0	0	1	20	4	1	1990
			1991		1	1	0	0	0	0	1	0	22	3	--	1991
Bullion Park	LP	12.7	1989	25	0	1	4	0	2	0	3	15	0	20	5	1989
			1990		0	0	2	0	1	0	0	0	22	3	--	1990
			1991		0	0	0	0	0	0	0	0	25	--	--	1991
Granite Butte[1]	LP	11.4	1989	25	0	0	2	0	9	0	5	95	0	12	13	1989
			1990		0	0	0	0	0	0	1	0	24	1	--	1990
Porcupine Creek	LP	8.7	1989	25	0	0	4	0	8	1	10	2	0	24	1	1989
			1990		0	2	9	0	4	0	1	0	9	14	2	1990
			1991		0	0	0	1	5	0	3	0	16	9-	--	1991
			1992		8	1	0	0	0	0	0	0	16	9	--	1992
			1993		6	0	1	0	1	0	0	0	17	8	--	1993
Cave Gulch[1]	DF	12.1	1989	25	0	0	6	0	9	0	8	2	0	6	19	1989
			1990		0	0	1	0	2	0	0	10	12	11	2	1990
Copper Creek	ES	13.2	1989	25	0	2	3	0	8	0	0	12	0	23	2	1989
			1990		0	3	1	0	3	0	3	3	12	11	2	1990
			1991		0	1	4	0	0	2	1	0	17	8	--	1991
			1992		8	0	0	0	0	0	0	0	17	8	--	1992
			1993		6	0	0	0	0	0	0	0	19	6	--	1993
Betty Creek	WP	24.1	1989	25	0	0	1	0	3	0	10	11	0	25	0	1989
			1990		0	8	15	0	2	0	0	0	0	25	0	1990
			1991		12	1	3	0	1	0	0	0	8[2]	17	--	1991
			1992		10	0	0	0	0	0	0	0	15[2]	10	--	1992
			1993		10	0	0	0	0	0	0	0	15	10	--	1993

[1] Trees harvested prior to re-examination in 1993.
[2] Killed by mountain pine beetle.

Table 4--Estimates of crown condition and tree mortality of winter-damaged conifers in six stand assessment transects during 1989 and 1990.

		----Tree Species----						----------Crown Damage Rating----------										
Area	Year Exam.	LP	DF	AF	S	WB	L	Total	4,0	4,1	3,1	3,2	2,2	2,3	1,3	1,4	Dead	New Growth
		----------Number of Trees----------																
Bryan Creek	1989	100	--	--	--	--	--	100	0	19	23	0	23	0	21	14	0	57
	1993	100	--	--	--	--	--	100	21	0	0	0	0	0	0	0	79	21
Bullion Park	1989	96	0	3	1	0	0	100	0	30	32	0	18	0	14	6	0	72
	1993	100	--	--	--	--	--	100	32	0	0	0	0	0	0	0	68	32
Porcupine Cr.	1989	100	--	--	--	--	--	100	0	3	34	0	31	0	17	15	0	88
	1993	100	--	--	--	--	--	100	71	0	2	0	3	0	0	0	24	76
Copper Creek	1989	29	1	32	37	--	1	100	0	21	28	0	24	0	5	22	0	71
	1993	31	1	34	34	--	--	100	50	1	0	0	1	0	0	0	48	52
Cave Gulch[1]	1989	56	44	--	--	--	--	100	0	12	26	0	23	0	18	21	0	18
Catract Creek[1]	1989	94	--	--	--	6	--	100	0	0	13	0	43	0	22	22	0	86

[1] Stands harvested prior to 1993.

Figure 2--Initial winter injury to ponderosa pine, 1990.

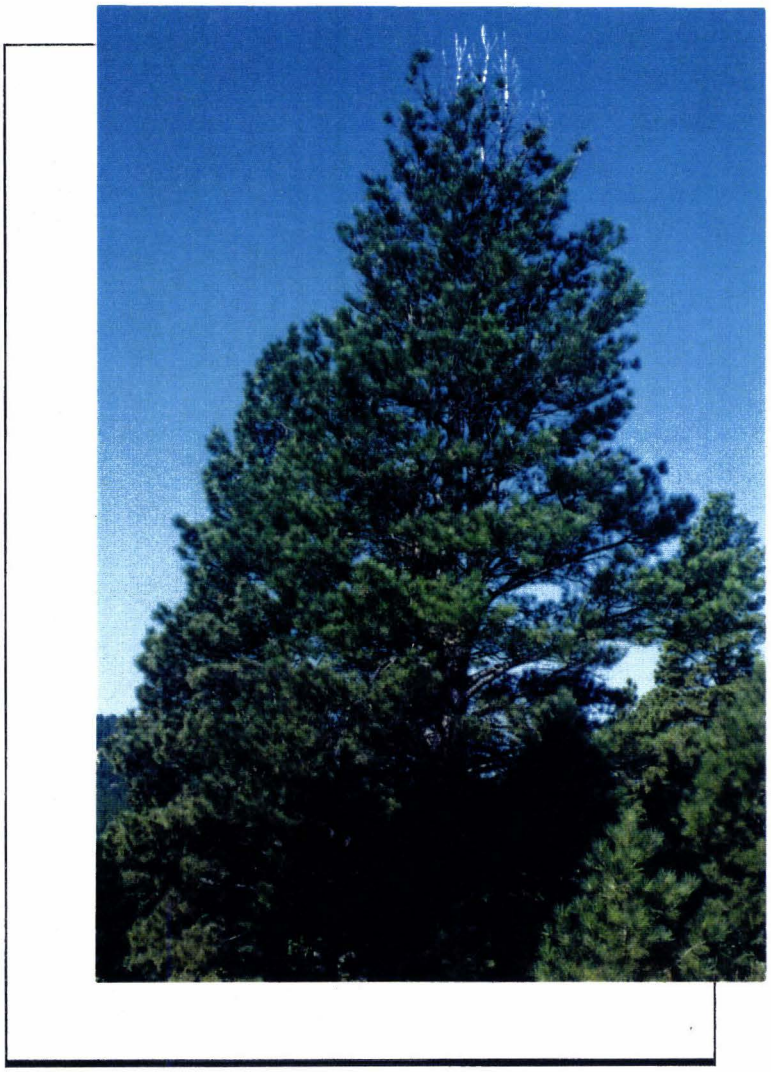


Figure 3--By 1994, many individual ponderosa pines that appeared to be critically injured in 1990 survived and showed insignificant long-term effects from winter injury.

The new growth of western larch, a minor component in the Copper Creek assessment plot, was severely stunted and "bushy" due to a proliferation of adventitious budding. Observations indicated that all reproductive buds of western larch in Montana during 1989 were almost totally destroyed.[5]

In many exposed areas and along roadsides, tree crowns projecting above an insulating snow layer, were badly damaged or killed outright. This phenomenon, known as "Krummholz" (Figure 4), was particularly visible in subalpine fir in parts of Glacier National Park.

Some additional physical characteristics of the affected trees in and adjacent to the survey areas were noted during the survey.

In most of the lodgepole pine areas, beginning in 1990, practically all of the dying trees produced prolific cone crops (first year) in the upper crown, a sign of the severe stress.

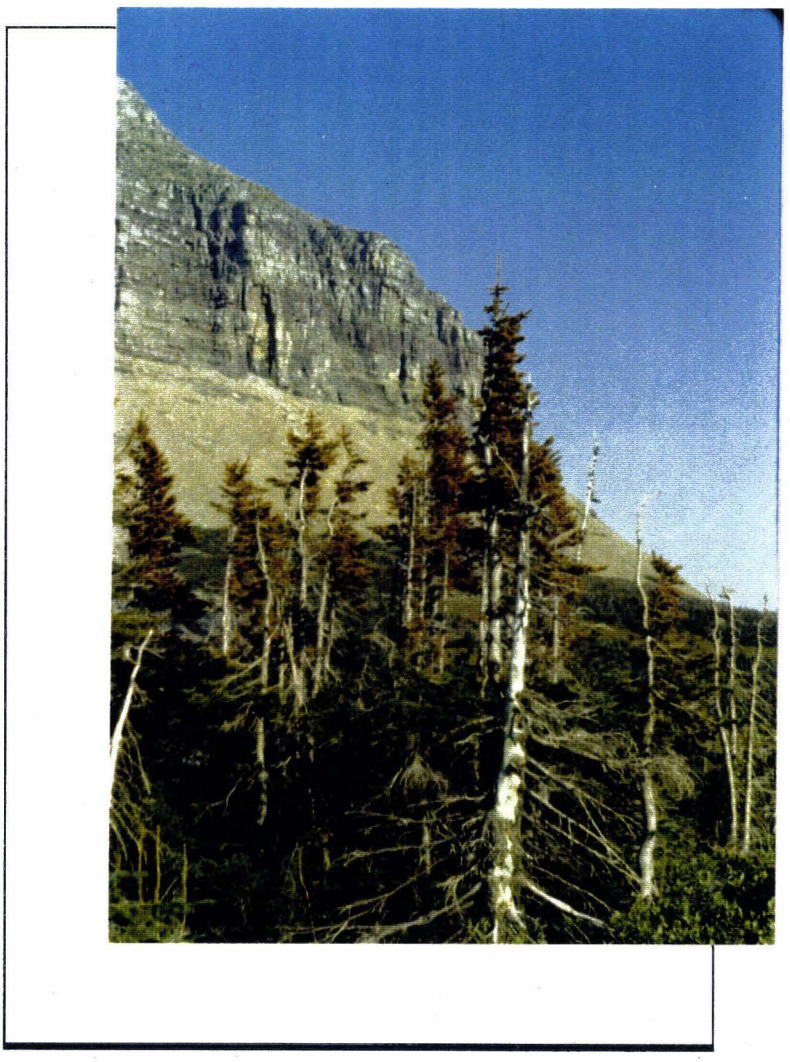


Figure 4--A phenomenon known as "Krummholz" was visible in subalpine fir on parts of Glacier National Park

In 1990, during the first re-examination, the lower boles of many lodgepole pine and some Engelmann spruce were saturated with moisture (Figure 5), and when pierced with a hatchet, would exude copius liquid. In some lodgepole pine, this fermented exudate had the color and consistency of vanilla custard.

Figure 5--The lower bole of an Engelmann spruce that was saturated with moisture shortly after the winter injury.

In bark-beetle-killed lodgepole pine, the outer bark will adhere to the inner bark for years, but this is not the case with winter-killed lodgepole pine. Once dead, the outer bark separates, begins to slough off in large pieces leaving the inner bark (wood) smooth and practically unmarked. In nearly all cases, no secondary insect activity occurred in the subcortical region.

Unlike lodgepole pine, Douglas-fir were attacked by DFB following the winter damage. Prior to 1989, aerial survey did not detect DFB in Kershaw mountain area.

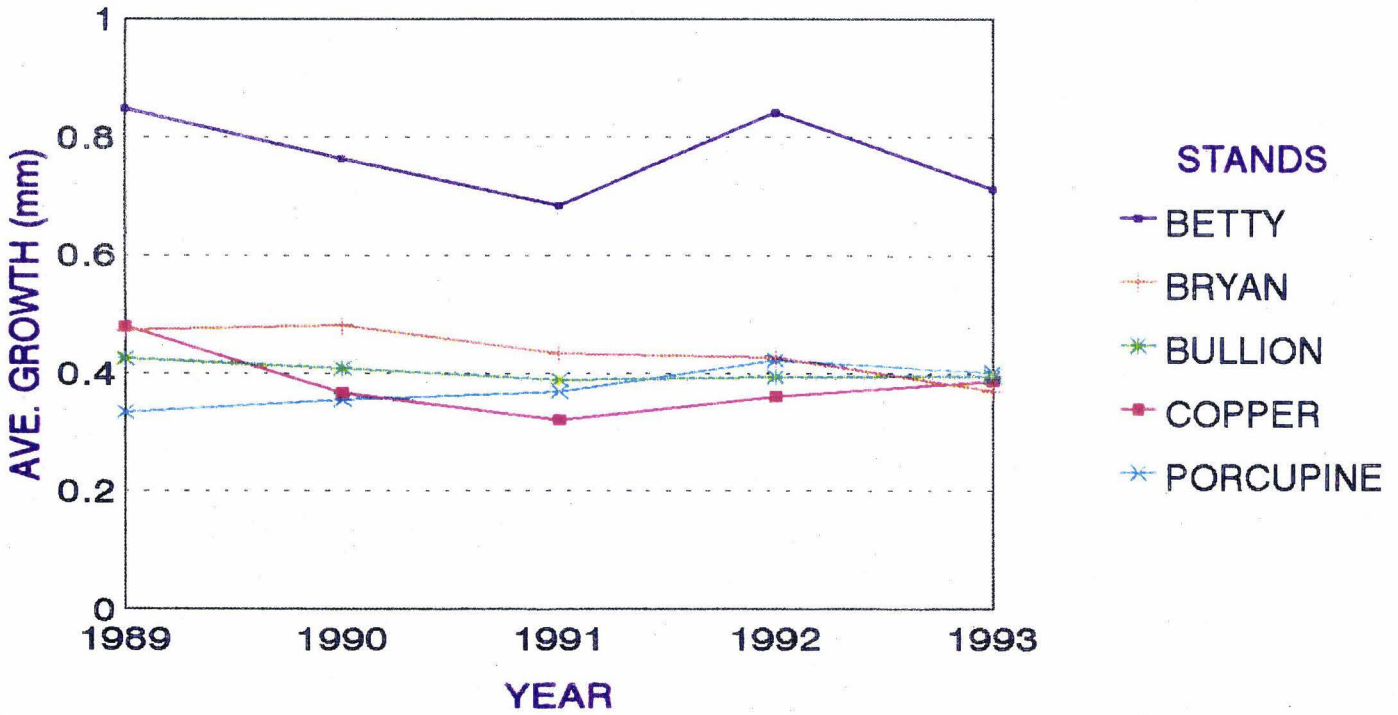
The least decline in growth occurred in lodgepole pine, followed by Engelmann spruce and then white pine. In lodgepole pine, there were no differences in growth relative to host tree age. White pine growth declined by approximately 40 percent following the winter injury over a 5-year period. The average growth decline across species and stands was 22 percent (Table 5). In lodgepole pine, average growth for the 5-year period following the winter injury, either remained relatively the same, or slightly increased (Figure 6). In only one of the three lodgepole pine stands, growth declined the year following the winter injury. For both Engelmann spruce and white pine, growth declined significantly the year following the winter injury and through 1991. For both species, growth began to improve in 1992. In 1993, growth declined for white pine, and continued to improve for Engelmann spruce.

[5] *Personal communication with Clint Carlson, Intermountain Forest and Range Experiment Station, Missoula, MT.*

Table 5--Average growth for 5-year period prior to and following 1989.

Stand	Species	Average Age of Trees (yrs)	Average Growth for 5 yr (mm) Prior - 1989	Average Growth for 5 yr (mm) After - 1989
Betty Cr.	WP	64	1.25	0.76
Bryan Cr.	LP	105	0.39	0.44
Bullion Park	LP	116	0.39	0.40
Copper Cr.	ES	170	0.58	0.38
Porcupine Cr.	LP	134	0.39	0.38
Average Across Species and Stands			0.60	0.47

Figure 6--Average growth over a 5-year period following 1989 winter injury.



DISCUSSION

Commonly, winter damage to forests is termed "red belt" since damage is often visible along well-defined horizontal strata, but no such pattern was evident in this occurrence. The discernible pattern was that the bulk of injury appeared in and near the Continental Divide. In relation to individual occurrences, the winter injury affected most native conifers in mature and over mature stands, without respect to elevation, aspect or topographic position.

During the 5-year observation period, very little, if any, insect activity was observed in or near the affected lodgepole pine and spruce stands immediately following the winter damage. In lodgepole pine, some secondary insects, namely *Ips* spp., red turpentine beetles, sequoia pitch moths and twig beetles were observed in very few heavily damaged trees that eventually died. The physical condition of most of the affected lodgepole pine trees that eventually died was not conducive to bark beetle survival. Lodgepole pine may be more susceptible to direct mortality from winter injury than thicker barked trees such as Douglas-fir. The thin bark on lodgepole may not protect the phloem adequately; therefore, mortality was almost immediate leaving inadequate phloem conditions for primary bark beetle attacks. This phenomena is also true with the effects from fire and lodgepole pine.

In western white pine, 15 out of 25 trees were attacked by MPB. Whether these trees would have been killed by the ongoing surrounding outbreak or that winter damage pre-disposed them to MPB attack is probable, but cannot be verified. However, it is highly probable that the combined effects of blister rust, drought and winter injury weakened mature and over-mature white pine and predisposed them to MPB attacks. More attacks on WWP were observed in the Betty Creek area (pers. comm., Ken Gibson) during the fall immediately following the winter injury.

In Douglas-fir, significant bark beetle activity was observed. Douglas-fir beetle is not a particularly aggressive beetle and outbreaks are almost always associated with disturbances such as drought, defoliation, and/or windthrow. Some of the injured trees were attacked by Douglas-fir beetle in 1989 and 1990. By 1992, there was approximately a 20-fold increase in the number of trees killed by DFB on the Helena, with a significant portion of those in winter-injured stands (pers. comm., Ken Gibson). Many of these trees were already weakened by western spruce budworm defoliation and drought. The winter injury may have been the final factor in their predisposition to DFB.

It was suspected and confirmed that winter injury of Douglas-fir would have a negative impact on western spruce budworm populations in many of the budworm-infested, winter-injured stands. Over-wintering larvae can withstand extreme cold, but during the food-seeking, migratory stage in the spring, many larvae starved due to the absence of new foliage (reproductive and vegetative buds). In upper Orphir Creek on the Helena National Forest (Cave Gulch plots) for example, previously abundant western spruce budworm populations were practically non-existent in 1990. By 1992, budworm populations were re-bounding in winter-injury stands.[6]

We can only speculate on the long-term effects of this winter injury. We should mention that stands examined were those that received the most injury, and they represent only a small fraction of the total area affected in some degree by this meteorological phenomena. It is likely that many additional mature and over-mature stands that were enveloped by this arctic air mass suffered some degree of injury, but not as severe or visually obvious as those examined on the ground or mapped from the air during this study. This damage, when it occurred, was more subtle--varying amounts of injured and dead needles, sporadic bud kill and retarded or non-existent shoot growth. The result being reduced growth and vigor of many stands that were already in a state of decline from 3 successive years of drought. From our results of the growth analysis, we would expect that the trees will continue to improve in growth performance or remain the same. Growth in lodgepole pine will probably continue to remain the same due to the older age of the trees. In the Engelmann spruce and white pine stands, we cannot be sure if growth will improve or decline. A second growth analysis would be worthwhile in 5-years to follow the growth trends/patterns of these two species.

[6] Personal communication with Lawrence E. Stipe; Entomologist; Timber, Cooperative Forestry and Pest Management; USDA Forest Service, Missoula, MT.

In the absence of practical silviculture applications to improve the health of these winter-injured stands, they will continue to be vulnerable to injury as well as ready hosts to insects and diseases.

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APPENDIX

Location and other data pertinent to stand damage assessment and re-examination plots.

			Survey Type[1]					
No.	Forest	Area	A	R	Tree Sp.[2]	Elev. (ft.)	Aspect	Geographic Description
1	Helena	Bryan Cr.	X	X	LP	6400	S	T.8N, R.6W., S½ Sec.3
2	Helena	Bullion Park	X	X	LP	6700	SW	T.8N, R.6W, S½Sec.2
3	Helena	Cave Gulch	X	X	DF	6420	NW	T.11N., R.7W., S½ Sec.6
4	Helena	Copper Cr.	X	X	S	5540	NNW	T.15N., R.9W., S½ Sec.2
5	Deerlodge	Porcupine Cr.	X	X	LP	6400	NE	T.5N., R.5W., S½ Sec.3
6	Deerlodge	Cataract Cr.	X			7400	NW	T.7N., R.5W., S½ Sec.3
7	Helena	Granite Butte		X	LP	6900	W	T.13N., R.7W., S¼ Sec.27
8	Flathead	Betty Cr.		X	WP	3800	SW	T.28N., R.7W., NE¼ Sec. 28

[1] A = Stand damage assessment; R = Re-examination.

[2] Tree species - Re-examination plots only. See Table 4 for tree species examined during assessment surveys.